Hahne, Jochen

# Degradation of dust in waste air scrubbers

Dust from waste air of animal husbandries can be separated to a very large extent by scrubbers. But this arises the question according the disposition of the separated dust. Lab scale results showed for an estimated dust separation efficiency of 90 % that approximately 27 % of dust mass was dissolved, while 63 % was scarcely soluble and therefore it could also be deposited as solid matter on the packing material. The solids were subject to a heavy bulking, which could result in a considerable weight increase of the packing material and a decline of its clear diameter. Both aspects have to be accounted for the dimensioning of waste air scrubbers.

**Keywords**
Waste air treatment, dust, degradation, bulking

**Abstract**
Landtechnik 64 (2009), no. 2, pp. 95 - 97, 3 figures, 1 table, 4 references

Waste air from pig fattening comprises among odorants ammonia and other trace gases also dust. The mean dust concentration in pig stables was indicated for Northern Europe to be 2.19 mg/m³ for inhalable dust and 0.23 mg/m³ for respirable dust [1]. Own total dust measurements at a pig fattening resulted in values in a range from 0.32 to 11.66 mg/m³ and 2.41 mg/m³ in mean, respectively (n = 44) [2].
In experience of the DLG approval tests at least 90 %, and up to 98 % in parts, of the total dust was separated if the animal husbandry was connected with a properly dimensioned and operated waste air scrubber [3, 4]. In face of this good emission reduction the question concerning the disposition of the separated dust comes up.

## Aims

Aim of the work was by means of lab scale investigations to get information about the dust composition as well as its behaviour in the waste air treatment system.

## Results

Dust from a pig fattening can be characterised as a mixture of a water soluble, easy degradable fraction and a scarcely soluble and hence hardly degradable portion **(Table 1)**.

The rapid water soluble fraction of the separated dust amounted to 27 % of the dust mass and caused about 25 % of the Chemical Oxygen Demand of the total dust. The soluble portion could be oxidized within 5 days with an efficiency of more than 87 % by microorganisms living in the washing liquid, as the $BOD_5/COD_c$ ratio shows. Scarcely 7 % of the dust mass was organic bond nitrogen and 1.7 % was phosphorus. Dust reacted slightly alkaline if it was suspended in deionised water (pH value = 7.7) but it released only few salts as conductivity measurements showed. The electric conductivity increased by 0.06 mS/cm with suspension of 1g/l dust.

The microbiological dust degradation can be measured with the Biological Oxygen Demand in five days ($BOD_5$). According measurements with adapted biomass from a trickle bed reactor which is used for cleaning of waste air from piggeries showed a strict logarithmic coherence between oxygen consumption and incubation time ($R^2 = 0.99$, n = 10). The degradation rate already declined below 2 %/d after seven days and below 1 %/d after thirteen days **(Fig. 1)**. On the basis of current data the degree of degradation would be below 50 %, even after 50 d of incubation.

Table 1

*Composition of dust from a pig fattening*

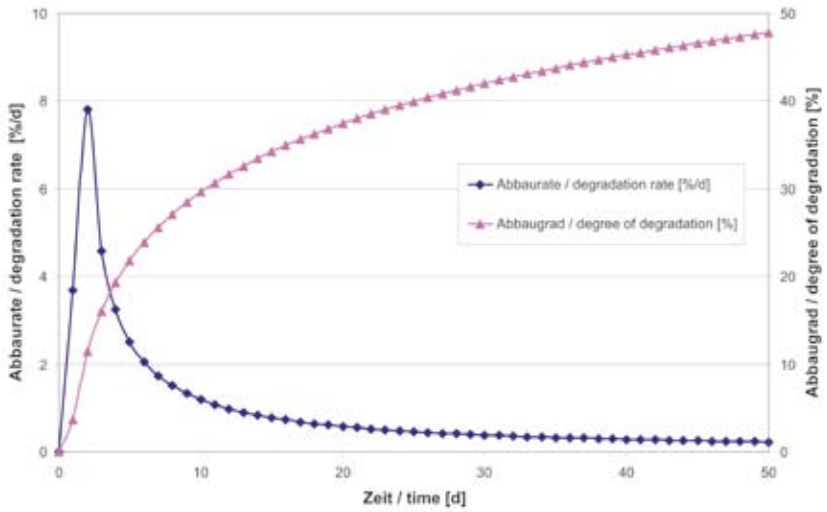
| Parameter | Unit | Value |
|---|---|---|
| Bulk density | [g/l] | 365 |
| Water absorption | [g/g DM] | 2.2 |
| Dry matter (DM) | [%] | 98.8 |
| $NH_4$-N | [mg/g DM] | 1.4 |
| Organic nitrogen | [mg/g DM] | 67.3 |
| P, dissolved | [mg/g DM] | 6.8 |
| P, total | [mg/g DM] | 16.7 |
| Biochemical Oxygen Demand in five days ($BOD_5$) | [mg $O_2$/g DM] | 314 |
| Chemical Oxygen Demand, centrifugated ($COD_c$) | [mg $O_2$/g DM] | 359 |
| Chemical Oxygen Demand, total (COD) | [mg $O_2$/g DM] | 1410 |

For the praxis these results mean that dust which is incorporated in a waste air treatment system is badly degradable besides a small rapid soluble and degradable fraction.

On the basis of present results it can be emanated from a dust reduction of 90 % at properly operated waste air scrubbers. A smaller portion of the separated dust will be rapidly solved (27 %), the bigger fraction will however be suspended in the washing liquid or deposited on the packing material **(Fig. 2)**. Lab scale results showed that the non soluble fraction was subject to a considerable bulking, whereas the water absorption of the tested and dried dust was 2.2 g/g dust. Hereby the packing material can amount to a heavy increase in weight, which absolutely has to be considered in dimensioning as the following rough calculation shows.

Taking a total dust concentration of 2.2 mg/m³ and a mean filter volume load of 2500 m³/m³ h as a basis, the dust input per m³ packing material would be 132 g/d. While 13.2 g/d would be emitted with the clean gas, 118.8 g/d would be separated, whereas 35.6 g/d of it will be dissolved and degraded and 83.3 g/d will be deposited or suspended. The latter fraction is subject to a heavy bulking which may result in a triplication of the mass.

Fig. 1




*Microbiological degradation of dust from a fattening pig stable with adapted biomass*

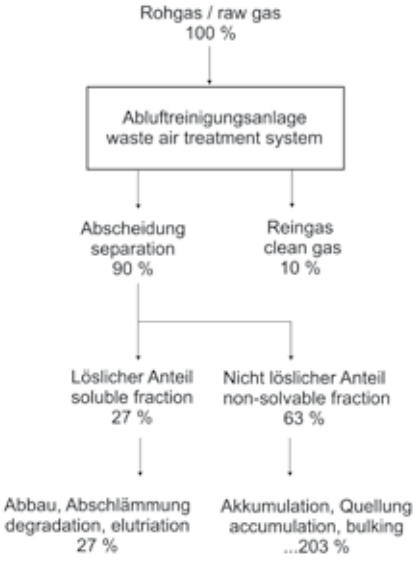
Thus the weight of 1 m³ packing material can increase about approximately 27 kg within 100 d, only by dust depositing. The bulking can also result in a considerable reduction of the clear diameter of the packing material and thus it may contribute to increased pressure drops.

The dissolving of initially non soluble fractions in water is the precondition of a microbiological dust degradation. Lab scale results showed in this regard that the portion of oxidisable compounds (measurable as Chemical Oxygen Demand, COD) increased with the lifting of the pH value by addition of sodium hydroxide solution (NaOH) **(Fig. 3)**. If, for example, the pH value was lifted from approximately 8 (untreated dust suspension in water) to 9 with sodium hydroxide solution the portion of soluble COD increased about 26.5 %. At pH values about 12 the soluble COD increased more than 110 %, relating to the initial value. This may be of use for possible cleaning of the packing material. Additional lab scale results showed that after an alkaline cleaning the pH value declined again within 2 d from 10.3 to 6.7 or from 11.9 to 7.7 in 6 d . This is caused by carbon dioxide absorption as well as resurged microbiological dust degradation.

## Conclusion

Dust will be separated very efficiently from waste gas by biological working and properly operated scrubbers. Approximately 27 % of the separated dust will be dissolved in the washing liquid, degraded and discharged with the elutriation, while 63 % are

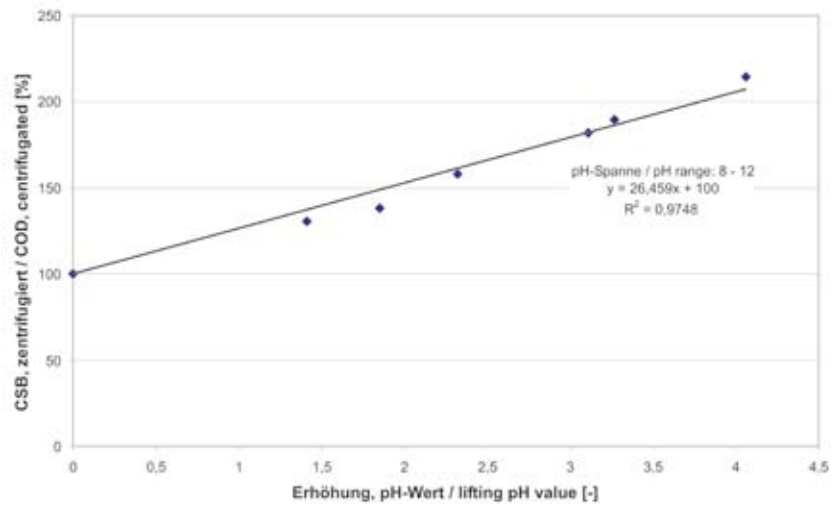
Fig. 2




*Flow sheet regarding the separation and disposition of dust in biological waste air scrubbers at the pig fattening*

scarcely soluble and therefore be suspended in the washing liquid or deposited on the packing material. Dust, deposited in and on the packing material, can result in a considerable weight increase of the packing material by bulking on the one hand and otherwise, it may contribute to blockages. Therefore a sufficient voids fraction of the packing material and a sufficient mechanical stability should be regarded during dimensioning. Lab scale results show that dust can be dissolved better with an increasing pH value (pH range 8-12). This may be of use for possible cleaning of the packing material.

Fig. 3




*Increase of dissolved COD by lifting the pH value in an aqueous dust suspension*

## Literature


[1] Takai, H.; Seedorf, J.; Pedersen, S. (1999): Dust and endotoxin concentrations in livestock buildings in Northern Europe. Proceedings of Int. Symposium on Dust Control in Animal Production Facilities. Scandinavian Congress Center, Arhus, Denmark, ISBN: 87-88976-35-1

[2] Hahne, J.; Asendorf, W. Sind Abluftwäscher zur Minderung von Staubemissionen geeignet? Landtechnik 61 (2006), H. 2, S. 88-89

[3] DLG e.V.-Testzentrum Technik und Betriebsmittel: Abluftreinigungsanlage „Dorset-Rieselbettfilter". DLG-Prüfbericht 5702, Groß-Umstadt 2006

[4] DLG e.V.-Testzentrum Technik und Betriebsmittel: Abluftreinigungsanlage „Zweistufige Abluftreinigungsanlage Chemowäscher (+)". DLG-Prüfbericht 5629, Groß-Umstadt 2006


## Author


**Dr. rer. nat. Jochen Hahne** (e-mail: jochen.hahne@vti.bund.de) is a scientific associate at the Institute of Agricultural Technology and Biosystems Engineering at the Federal Research Institute for Rural Areas, Forestry and Fisheries (Johann Heinrich von Thünen-Institute), Bundesallee 50, D-38116 Brunswick, Germany